June 19, 1856.

The LORD WROTTESLEY, President, in the Chair.

The following gentlemen were admitted into the Society:—

John Carrick Moore, Esq.
Edmund Potter, Esq.
Henry Hyde Salter, M.D.

The following gentlemen were recommended by the Council for election as Foreign Members:—

Wilhelm Karl Haidinger.
Antonio Secchi.

The following communications were read:—

I. "On Colour-Blindness." By WILLIAM POLE, Esq., F.R.A.S., F.G.S., Memb. Inst. C. E. Communicated by CHARLES MANBY, Esq., F.R.S. Received June 7, 1856.

(Abstract.)

The author's object in this paper is to state his own case of colour-blindness, which he believes to be one of the most decided on record; to compare it with others of the same kind; and to show that the general phenomena attending this defect of vision are more uniform and consistent, as well as more easy of explanation, than is generally supposed.

For general information on the subject, reference is made to a work lately published by Dr. Wilson of Edinburgh, entitled "Researches on Colour-Blindness," in which a great number of cases are fully described, and the optical and physiological theories of the defect carefully discussed.

After stating reasons which justify a colour-blind person undertaking the investigation and description of his own case, the author gives a preliminary statement of his views in regard to the general theory and nomenclature of colours, adopting the ordinary hypothesis that red, blue, and yellow are the three primaries; a theory which, though it has been lately called in question, receives, it is considered, new support from the phenomena of the defect of vision under consideration.

Dr. Wilson describes colour-blindness as of three kinds, namely—

1. Inability to discern any colour except black and white. This is very rare.
2. Inability to discriminate between the nicer distinctions of colour. This is so common as to be apparently rather the rule than the exception.
3. The third variety is the only one here treated of. Its outward manifestation is the inability to distinguish between many of the colours most marked to normal eyes, and its most complete form is what is called *dichromic* vision; being total blindness to one of the three primary colours.

The description of a case of colour-blindness may either be confined to a statement of what may be called the *symptoms* of the malady, i. e. the effects it produces on the individual's judgment of colours; or it may go further, and endeavour to describe the positive nature of the *sensations* experienced, the causes, so to speak, of the outward symptoms observed. The first is the plan usually adopted, but the author combines both in the account of his own case.

As regards the outward symptoms, he finds them very similar to those of other cases; and for the purpose of showing this similarity, he collects in an appendix the principal features of nearly forty published cases, and points out that as a general rule he can corroborate the whole from his own impressions, the points where they appear to differ being very few and exceptional.

An abstract is then given of the symptoms exhibited, as collected from these cases. They are as follows:—

Blue and yellow are perfectly distinguished, and are the only colours seen in the spectrum.

Almost all colour-blind persons think they see red, but it is frequently confounded with green (the most common mistake),

black, orange, yellow, brown, blue and violet. Crimson and pink appear to have no relation to scarlet.

Green is a most perplexing colour; it is not only confounded with red, but with black, white, or grey, orange, yellow, blue, violet and brown.

Violet is confounded with blue or grey; and orange with yellow.

More difficulty is manifested with light or dark tones of compound colours than with full ones.

In explaining more accurately the real nature of the author's vision of colours, he employs as standard examples of reference the "Cercles Chromatiques," and "Gammes Chromatiques" of M. Chevreul (copies of which accompany the paper), the former giving various gradations of *hue*, the latter, gradations of *tone*. He states that his vision is perfectly *dichromic*, and shows the applicability to it of the definition of this kind of vision given by Sir John Herschel, which he believes has never hitherto been followed out so completely as is necessary to explain the phenomena observed.

Blue and *yellow* he sees perfectly well, and has no reason to doubt that his sensations of these two colours are the same as those of the normal-eyed. The third primary, *red*, is the one in regard to which his vision is defective, but the study of the sensations produced by this colour has been involved in some difficulty. Carmine, the artificial representative of what is usually considered pure red, presents to the author's eye a very positive sensation, which he long supposed to be a distinct colour; but on examining it more closely, he found it to be merely a dark shade of yellow, as he could match carmine red perfectly with a mixture of yellow and black. There is, however, a variety of red, namely *crimson*, which is perfectly invisible, as a colour, to his eyes, giving only a sensation of darkness; and the whole of the hues of red and orange between this and yellow present only different *shades* of the latter colour; the red element appearing to act, not as a colouring agent, but simply as a darkening power. The author has endeavoured to find the place of this, to him, neutral or invisible hue of red on the spectrum, and believes that if it exists there at all, it must be situated at one or both of the extreme ends, a position which would appear to distinguish it as possessing some peculiar property, and he offers a conjecture that this, and not carmine red, may perhaps be the true primary colour.

The hues of *violet*, lying between blue and crimson, appear, on a similar principle, only shades of blue, the red darkening the blue in the same manner as the yellow.

In passing on to the *green* division of the colour circle, lying between the blue and yellow, the author calls attention to the apparent anomaly, that though colour-blind persons see blue and yellow perfectly well, their combination, green, should be so great a stumbling-block. This fact appears to have perplexed everybody who has treated on the subject; the author imagined he was the first to discover the explanation, but he found he had been anticipated by Sir John Herschel, who says in his letter to Dalton, "the equilibrium of blue and yellow *produces your white*," i.e. the white of the colour-blind is not white at all, but *green*. And this is consistent with theory; for if normal white is a combination of three elements, the invisibility of one of these elements to the colour-blind should naturally have the effect of changing the appearance of their compound. Since, therefore, green is only a *colour* to the normal-eyed as it is contrasted with white light, it becomes no colour at all to the colour-blind. The author proves this by showing that a certain hue of green exactly matches, to his eyes, a neutral grey; that all greens on the yellow side of this appear only shades of yellow, all on the blue side, only shades of blue.

Thus the dichromic explanation of the author's vision is complete. He has only two sensations of colour, properly so called, namely blue and yellow, all other hues in nature being reduced to *shades* of these. The colour of light, or the hue resulting from their combination, may be called green, white, or grey, at pleasure. It is shown that this explanation of colour-blind vision will fully account for the whole of the various symptoms above enumerated. Red and green, for example, are both seen only as shades of yellow, and if the yellow is of the same intensity in each, they will appear alike, and of course be confounded with each other.

The author then proceeds to consider how far his own case may be regarded as a type of the defect in general. The varied and incongruous nature of the symptoms has given rise to a belief that there are many varieties of colour-blindness, or at least many different degrees of severity; but after carefully examining the published accounts, he has arrived at the conviction that the true di-

chromic affection is much more common than is generally supposed. He points out reasons why the descriptions given by the colour-blind of their sensations may often be imperfectly expressed and easily misunderstood, alludes to the difficulty of explaining the symptoms by any other hypothesis, or even of classifying them in any consistent way; and considers the fact exemplified in his own case, that dichromic vision will explain all the phenomena, as strongly corroborative of the uniformity insisted on.

From the results of his investigations, the author draws a few inferences in regard to the theory of the primary colours, although admitting his incompetence to deal fully with this part of the subject. He considers that, from the extreme simplicity of the phenomena of colours as seen by the colour-blind, their experience may serve as a stepping-stone to the more complex problems of normal vision. Their light is divisible into two colours, blue and yellow; and since these must be undoubtedly primaries to the colour-blind, it is reasonable to infer they should also be primaries in the normal system. The dichromic eye further becomes of use as an analyser of colours, and can detect the presence of blue or yellow in compounds whose elements may be inseparable to normal eyes. Thus it finds that in orange there is much yellow, and in violet much blue, and therefore these cannot be simple colours. Red, producing no impression on the colour-blind eye, may be assumed to be a simple colour, and may therefore be put down as the third primary, so that the phenomena of colour-blindness would appear to confirm the ordinary theory, or at least are more consistent with it than with any other. The fact of carmine-red presenting to the colour-blind a decided sensation of yellow, affords a confirmation of Sir David Brewster's theory of the triple spectrum, according to which this result ought to be expected.

The principal symptom of colour-blindness being the mistaking of red for green, and *vice versâ*, it has been thought that the use of these colours for railway and ship signals becomes dangerous where colour-blind persons may have to observe them. The author points out that this danger may be obviated by very simple means. Red and green are not confounded with each other generally, but only such hues of them as lie in both cases on the yellow side of the neutral; and therefore if the green be made a *blue* green at the same

time that the red is a *yellow* red, they become quite as distinct to the colour-blind as to the normal-eyed.

The colouring of geological maps is very perplexing to the colour-blind, and it is recommended that engraved marks, to distinguish the different strata, should always be added to the colours.

In conclusion, the author gives hints which he considers useful for the examination of colour-blind persons, and states the importance of collecting further evidence on the subject, of an accurate and definite nature.

II. "Researches on the Velocities of Currents of Air in Vertical Tubes, due to the presence of Aqueous Vapour in the Atmosphere." By W. D. CHOWNE, M.D. Communicated by JOHN BISHOP, Esq., F.R.S. Received May 22, 1856.

(Abstract.)

This was a paper supplementary to one presented June 14th, 1855, an abstract of which was published in the 'Proceedings of the Royal Society' for June 21st, 1855. The author having ascertained that an upward current of air becomes established in a vertical tube placed in as quiescent an atmosphere as can be obtained, and having demonstrated its existence by means of anemometric discs placed in tubes as described in that paper, proceeded to ascertain the velocity of the currents by which the discs were moved.

In order to estimate the velocity of the currents, one of the anemometric discs was placed within a short zinc tube three inches in diameter, the lower end of which was accurately fitted into an aspirator capable of containing thirty-six gallons of water. By drawing off in a given time a quantity of water equal in bulk to the cubic contents of one of the tubes described in the former paper, the velocity of a current required to produce a given number of rotations of the disc was determined.

The experiments were varied by altering the height of water in the aspirator, and thereby changing the velocity, while the exit-orifice remained unaltered.

By ascertaining the number of rotations of the anemometric disc,